1 **LOCATION PATTERNS AND METHODS AND APPARATUS FOR**
2 **GENERATING SUCH PATTERNS**
3
4 CROSS REFERENCE TO RELATED APPLICATIONS
5 This application is related to the following Patent Applications: US Patent
6 Application Serial No._____ filed September 10, 2003, entitled
7 "Printing Digital Documents" (HP reference 200207150-1; Attorney docket
8 621239-6); US Patent Application Serial No._____ filed
9 September 10, 2003, entitled "Methods and Apparatus for Generating
10 Images" (HP reference 200207059-1; Attorney docket 621240-1); US
11 Patent Application Serial No._____ filed September 10, 2003,
12 entitled "Location Patterns And Methods And Apparatus For Generating
13 Such Patterns" (HP reference 200310542-1; Attorney docket 621241-9),
14 the disclosure of which is hereby incorporated herein by reference; British
15 Patent Application No._____ filed September 10, 2003, entitled
16 "Methods, apparatus and software for printing location pattern" (HP
17 reference 200300566-1; Attorney docket JL3824), the disclosure of which
18 is hereby incorporated herein by reference; and, British Patent Application
19 No._____ filed September 10, 2003, entitled "Printing of
20 documents with position identification pattern" (HP reference
21 200310132-1; Attorney docket ASW1329), the disclosure of which is
22 hereby incorporated herein by reference.
23
24 FIELD OF THE INVENTION
25 This invention relates to location patterns, typically printed on a
26 document and typically used to allow the position of a device such as
27 a pen to be determined relative to the pattern, and to methods and
28 apparatus for generating such patterns.
29
30 BACKGROUND TO THE INVENTION

1   The invention arose out of a consideration of the work of Anoto™

2   Group AB and others in relation to digital pattern paper and digital

3   pens. It is convenient to discuss the invention in that contextual

4   background, but it will be appreciated that the invention is not

5   restricted to use with any proprietary system.

6

7   The prior art Anoto digital pen and paper system is described on their

8   website www.anotofunctionality.com. However, since the content of

9   websites can change with time it is to be made clear that the prior art

10   admitted is that which was published on their website no later than

11   the day before the priority date of this patent application. It is also

12   appropriate to include in this application itself a brief review of the

13   Anoto system.

14

15   Figure 1a shows schematically part of an A4 sheet 10 of Anoto digital

16   paper. The sheet 10 has printed on it a part of a very large non-

17   repeating pattern 12 of dots 14. The dots 14 of the pattern 12 are

18   printed using infra-red absorbing black ink. The dots give the sheet

19   12 a pale grey appearance. An enlarged view of a small area of the

20   pattern 12 is illustrated in Figure 1b.

21

22   As is shown in the Figure 1b, the position identifying pattern 12 is

23   made up of a number of dots 14 arranged on an imaginary square

24   grid 16. The grid 16 can be considered as being made up of

25   horizontal and vertical lines 16a, 16b defining a number of grid

26   squares of side length 300μm, together with a number of

27   intersections 16c where horizontal and vertical lines cross. One dot

28   14 is provided at each intersection 16c, but offset slightly in one of

29   four possible directions; up, down, left or right, from the actual

30   intersection 16c. The dot offsets are arranged to vary in a

31   systematic way so that the pattern formed by any group of a

1   sufficient number of dots, for example a group of 36 dots arranged in

2   a six by six square, will be unique within a very large area of the

3   pattern.   An example of this type of pattern is described in

4   WO 01/26033.

5

6   Figure 2 schematically shows a digital pen 20 adapted to write

7   human readable ink in non-machine-readable IR transparent ink and

8   to read a position dot pattern in infra-red. The pen 20 has a housing

9   22, a processor 24 with access to memory 26, a removable and

10   replaceable ink nib and cartridge unit 28, a pressure sensor 29

11   adapted to be able to identify when the nib is pressed against a

12   document, an infra-red LED emitter 30 adapted to emit infra-red light

13   of a specified wavelength, an infra-red sensitive camera 32 (e.g. a

14   CCD or CMOS sensor), a wireless telecommunications transceiver

15   34, and a removable and replaceable battery 36. Such a pen exists

16   today and is available from Anoto as the Logitech IO™ pen.

17

18   The pen 20, when in use writing or marking the page 10, images a

19   6x6 array of dots 14. The pen's processor 24 establishes its position

20   in the dot pattern 12 from that image. The processor 24 processes

21   data   acquired   by   the   camera   32   and   the   transceiver   34

22   communicates processed information from the processor 24 to a

23   remote complementary transceiver (e.g. to a receiver linked to a PC).

24   Typically that information will include information related to where in

25   the dot pattern the pen is, or has been, and its pattern of movement.

26

27   Anoto intend that their digital paper, offset-printed with dot pattern,

28   either over the whole of its surface or over selected regions, be

29   available from specially registered printing companies who know the

30   technologies necessary to achieve good results. End users must buy

31   their paper pre-printed with machine-readable position dot pattern

1 and pre-printed with human readable content (e.g. text, or pictures,

2 or lines, or boxes or frames etc).

3

4 This is to avoid problems. One problem avoided by such a system is

5 that of users who design their own forms or documents, printing

6 human-discernable or readable content over the dot pattern with the

7 wrong ink (ink that is IR-absorbing ink), thereby masking the dot

8 pattern from the digital pen, when the pen is used.

9

10 Another problem avoided by such a system is that of the digital

11 pattern 12 being printed with characteristics that are different to

12 those required for it to be read by the pen 20. In the Anoto system,

13 as in other digital paper systems, the relative positions and sizes of

14 the elements of the pattern are controlled to be within pre-set

15 tolerances. In this manner, a pattern may be printed which conforms

16 to the specifications of the system and which is suitable for use with

17 the pen. In the case of the Anoto system, for example, examples of

18 elements of the pattern that are controlled to be within pre-set

19 tolerances include: the spacing between adjacent parallel lines of the

20 grid 16; the distance by which the dots 14 are offset from their

21 corresponding grid intersections 16c; and, the diameter of the dots

22 14. Many printers have technical characteristics which render them

23 unable to reliably print the elements of such a pattern, such that the

24 relative positions and the sizes of the pattern elements meet the pre-

25 set tolerances. Many existing home and office printers, for example,

26 are unable to reliably do so. For this reason, Anoto intend that the

27 digital pattern 12 is printed using offset printers, which are able to

28 print it with sufficient quality and with sufficient resolution in order

29 that it may be read by the pen without error.

30

31 SUMMARY OF THE INVENTION

1 According to a first aspect of the invention there is provided a printer

2 system comprising a printer and an ink supply, the printer arranged

3 to print a location pattern comprising a plurality of dots adapted to be

4 read by a pattern reader, the system being further arranged to modify

5 one or more characteristics of the dots substantially in dependence

6 upon the quantity of ink in the ink supply.

7

8 In general, the print quality of printers varies as components of the

9 printer age or wear. In cases such as laser printers and inkjet

10 printers, the print quality also varies with the degree of wear or

11 deterioration of the ink supply. In the case of an inkjet printer, the

12 ink supply is generally an ink cartridge which includes an ink drop

13 ejection mechanism. In the case of a laser printer, the ink supply is

14 generally a toner cartridge which includes, amongst other

15 components: a photoconductor; a developer roller; and, a cleaner

16 blade. All of these components deteriorate or wear with use and/or

17 cartridge life. In fact, the toner contained in the cartridge also

18 degrades with time. In the case of a laser printer, the deterioration

19 of a toner cartridge may produce any of various print defects, which

20 may include: banding; streaking; ghosting; visual noise; image

21 density changes; and, changes in printed image size and shape.

22

23 By modifying one or more characteristics of the dots in the location

24 pattern in dependence upon the degree of wear or deterioration of

25 the ink supply, the effects on printing performance of the wear or

26 deterioration of the toner cartridge may be compensated for. In this

27 manner, a dot pattern of a particular type may be printed in a

28 relatively stable manner. Furthermore, this may be achieved within

29 the specifications of the system across a greater proportion, or

30 indeed the entire life of the ink supply. This may extend the usable

31 life of the ink supply and reduce the operating costs for the user.

1

2 In embodiments of the invention, components of an ink supply may

3 be monitored in order to determine the current printing performance

4 using that ink supply. Alternatively, the output print quality may be

5 measured using conventional tests.   In either case, the

6 characteristics of the dots of digital patterns may be modified in

7 dependence upon the determined printing performance or print

8 quality or using that ink supply. However, in certain embodiments of

9 the invention, the degree of wear or deterioration is inferred from the

10 level of toner remaining in the toner cartridge of a laser printer. It

11 has been found that generally this gives a reasonably reliable

12 indication of the printing performance of a toner cartridge.

13

14 In one embodiment the modification of the one or more

15 characteristics of the dots in the location pattern is made

16 substantially at the time of printing, although in other embodiments it

17 may be made somewhat in advance of the time of printing.

18

19 In one embodiment, a dot characteristic that is modified in

20 dependence upon the quantity of ink in the supply, is the dot size. In

21 this embodiment, smaller dots are printed as the level of ink

22 remaining in the ink supply falls.

23

24 In one embodiment, when using certain laser printers, when the ink

25 supply is relatively full, the dots making up the digital pattern are

26 printed such that they are relatively large. As the toner cartridge

27 degrades with time and the level of remaining toner falls, the print

28 quality also falls. One result of the falling print quality in this case is

29 a change in the size of the printed dots, which tends to increase as

30 the toner cartridge degrades. In this embodiment, the printer system

31 is arranged to print with smaller dots (i.e. the print data sent to the

1 printer specifies smaller dots) as the toner cartridge degrades in
2 order to compensate for the increasing size of the printed dots.
3
4 In another embodiment, when the ink supply is relatively full the dots
5 making up the digital pattern are printed such that they are relatively
6 small. In certain systems, when the printer is printing normally, with
7 a relatively full ink supply, the size of the dots may have an upper
8 limit, above which they may not be reliably read by a pattern reader
9 of the system. Alternatively, or additionally, it may be desirable to
10 use a digital pattern made up of small dots in preference to one
11 made up of large dots, since small dots may interfere less than large
12 dots with any human discernable content printed on the same sheet
13 or carrier.
14
15 When the ink supply becomes relatively depleted, the printed output
16 of the printer may change relative to that produced when the ink
17 supply is not depleted. For example the printed output may become
18 faint, resulting in patters made up of small dots printed when the ink
19 supply is relatively depleted to be unreliably read by a pattern
20 reader. In this embodiment it has been found that the use of larger
21 dots when printing with a relatively depleted ink supply results in
22 printed patterns which may be reliably read by the pattern reader.
23
24 In other embodiments, the size of the printed dots is changed more
25 than once during the life of the ink supply. In some of these
26 embodiments, each change may adjust the dot size in the same
27 direction; for example, to be made smaller at each occasion, or
28 larger at each occasion. In other embodiments, the change may be
29 in a different direction to the subsequent change. It has been found
30 that some laser printers with use tend to print dots which initially
31 increase in size with cartridge life and then subsequently decrease in

1   size with cartridge life. Such an embodiment may be used with

2   benefit in such situations.

3

4   In other embodiments, the effect of varying print quality caused by

5   other factors is compensated for.

6

7   The present invention also extends to: software or a printer driver for

8   generating such a location pattern; and, corresponding methods for

9   generating or printing such location patterns; as defined in the

10   appended claims.

11

12   BRIEF DESCRIPTION OF THE DRAWINGS

13   For a better understanding of the invention and to show how the

14   same may be carried into effect, there will now be described by way

15   of example only, specific embodiments, methods and processes

16   according to the present invention with reference to the

17   accompanying drawings in which:

18

19   Figure 1a shows schematically a sheet of Anoto digital paper;

20

21   Figure 1b shows schematically an enlarged portion of the sheet

22   illustrated in Figure 1a;

23

24   Figure 2 shows schematically a known digital pen;

25

26   Figure 3 shows schematically a system for creating and printing

27   digitals document according to one embodiment of the invention;

28

29   Figure 4a is a flow diagram showing a method of designing an

30   electronic document according to an embodiment of the present

31   invention;

1

2 Figure 4b is a flow diagram showing a method of generating a digital

3 pattern and digital document according to an embodiment of the

4 present invention;

5

6 Figures 5a and 5b schematically illustrate exemplary digital

7 documents printed according to embodiments of the present

8 invention; and,

9

10 Figures 6a and 6b are schematic illustrations of dots forming

11 exemplary portions of digital patterns printed using methods

12 according to embodiments of the present invention.

13

14 DETAILED DESCRIPTION OF THE INVENTION

15 There will now be described, by way of example only, the best mode

16 contemplated by the inventors for carrying out embodiments of the

17 invention.

18

19 Figure 3 is a schematic illustration of a system 50 for printing a

20 document having a pattern, according to an embodiment of the

21 invention.

22

23 The system 50 comprises a workstation 51 including a personal

24 computer (PC) 52 which is connected to a local printer 60.   In

25 practice, the printer may instead be connected to the PC 52 via a

26 network. The PC 52 may also be connected to the Internet 62. The

27 PC 52 includes a user interface including a screen 58, a keyboard 54

28 and a mouse 56. The PC 52 has as a processor 52a, a memory 52b,

29 and I/O software devices 52c by means of which the processor

30 communicates with the screen 58, the keyboard 54 and the mouse

31 56 and a communications port 57 by means of which it

1   communicates with the Internet 62 or a local network such as a

2   LAN 59 having peripheral devices and/or other computers (e.g. PCs)

3   59a.

4

5   The workstation 51 has access to a database 52d of pattern data for

6   use with Anoto-type digital documents. The database 52d may also

7   have user names and identification numbers, which are in use

8   associated with each particular document at the time of printing of

9   the document and which may be printed out with the document. This

10   database 52d may be on the PC or elsewhere on a network, for

11   example on a local file server or on the Internet. This may take the

12   form of a digital pattern space allocation server as is used in the

13   Anoto system. The PC 52 also includes a software tool, known as a

14   Print-on-Demand (PoD) tool, referenced 52e the figure. The PoD

15   tool 52e has access to the database 52d of pattern data, as is

16   described in more detail below.

17

18   The PC 52 is arranged to generate electronic digital documents that

19   comprise a pattern 12 of dots 14. The digital documents may be

20   "Anoto-type" digital documents. However, it will be appreciated that

21   the invention is not restricted to use with any proprietary system.

22

23   In certain embodiments of the invention, the digital documents may

24   be printed such that they have both a pattern 12 of dots 14 and

25   human-discernable content. The human-discernable content may

26   include amongst other things include text, graphics and check boxes,

27   for example. Figure 5a illustrates schematically a hard (paper) copy

28   of such a digital document. The hard copy comprises a carrier 70a in

29   the form of a single sheet of A4 paper, with the machine-readable

30   pattern 12 of dots 14 printed on it. In this example, the user has

31   defined the pattern area to cover the entire area of the carrier 70a,

1   as can be seen from the figure. Also printed on the paper 70a are

2   further markings 72a-c, which are clearly visible to a human user of

3   the form, and which make up the human-discernable content of the

4   document. In the example illustrated the content is made up of a

5   schematic image of a flower 72a, the word "SEND" 72b and a check

6   box 72c. The nature and amount of the content will depend entirely

7   on the intended use of the document.

8

9   Such digital documents may be used for specific functions, such as

10 questionnaires or forms, for example.   Suitable techniques for

11 simultaneously printing a digital pattern and human-discernable

12 content on printers, such as inkjet and laser printers, are more fully

13 described in co-pending British patent application, incorporated by

14 referenced above, entitled "Methods, apparatus and software for

15 printing location pattern", (Hewlett-Packard reference 200300566-1;

16 Attorney docket JL3824).

17

18 In certain methods of the invention, the digital documents are printed

19 with no, or substantially no human-discernable content. Thus, the

20 resultant printed digital documents in such methods are suitable for a

21 wide variety of uses by a user; i.e. they may be used as the digital

22 equivalent of blank notepaper. Figure 5b illustrates schematically a

23 hard (paper) copy of such a digital document. The hard copy again

24 comprises a carrier 70b in the form of a single sheet of A4 paper,

25 with the machine-readable pattern 12 of dots 14 printed on it. In this

26 example, the user has defined the pattern area to cover the entire

27 area of the carrier 70b, as can be seen from the figure. As can be

28 seen from the figure, there are no markings printed on the paper 70b,

29 for human use.

30

1   The user interface of the PC 52 allows a user to the view electronic

2   versions of digital documents to be printed, using a conventional

3   software viewer application, referenced 52f in Figure 3, on the screen

4   58.   An already existing, previously designed document may be

5   accessed from a database of such documents for printing.

6   Alternatively, a new document may be designed by the user.   The

7   user may make modifications to the digital documents prior to

8   printing them should this be required.   Such changes may include

9   modifying any human-discernable content that may be present in the

10   document or modifying the area or areas, in terms of size or shape

11   for example, on the digital document that are to have digital pattern

12   applied to them.   This may be achieved through the user interface,

13   which includes the keyboard 54 and mouse 56 and software (not

14   shown) for processing inputs from them, as well as the screen 58

15   and software 52g for producing the content, e.g. images and/or text,

16   on the screen.

17

18   Techniques for allowing a user to modify and print, on demand,

19   documents which have position identifying pattern on them for use

20   with a digital pen and paper system are more fully described co-

21   pending British patent application, incorporated by referenced above,

22   entitled "Printing of documents with position identification pattern",

23   (Hewlett-Packard   reference   200310132-1;   Attorney   docket

24   ASW1329).

25

26   Figure 4a is a flow diagram showing an exemplary method of

27   designing a generic electronic digital document suitable for use with

28   embodiments of the present invention.   The method starts at step 2

29   with the design of the human-discernable content of the document.

30   The design work is carried out on the PC using a software

31   application.   The application may, for example, be Acrobat Reader or

1   a word processing package such as 'Word', a database package
2   such as 'Access', or a spreadsheet package such as 'Excel'. Each of
3   these applications may be used to design the content of the
4   document. The content is converted to PDF format at step 4. It will
5   be understood that in the event that no human-discernable content is
6   incorporated into the documents, the steps 2 and 4 may be omitted
7   from the method.
8
9   The machine-readable pattern areas of the document are then
10   defined at step 6. In this case this is carried out using a form design
11   tool (FDT) 52h, shown in Figure 3, which in the present embodiment
12   is in the form of an Acrobat 5.0 plug-in. In one simple case, the
13   machine-readable pattern area of the document may be the entire
14   page; which may be a single A4 sheet for example. This may even
15   be set as the default setting at this step.
16
17   At step 8 the user allocates any desired computer-implemented
18   functions to one or more areas of pattern in the document. In this
19   manner, such a pattern area may code for instructions to perform the
20   associated function. For example, a "send" function may be
21   designated by a user to the pattern area associated with the box 72c
22   of the document 70a shown in Figure 5a, for example. In this way,
23   when the pen is used to check the box 72c, the system knows that
24   the updating of the document 70a is complete. In one simple case,
25   such a document need have no such computer-implemented
26   functions.
27
28   At step 10 a name is given to the document.
29
30   Once the user is happy with the design of the digital document, it
31   may be printed out.

1

2   The process of printing a document according to the present

3   embodiment, will now be described with reference to the flow

4   diagram in Figure 4b. In this example, a digital document consisting

5   of single sheet of A4 is printed. For the purposes of clarity, this

6   exemplary document has no human-discernable content and has a

7   machine-readable pattern of dots printed over its entire surface, such

8   as is illustrated in Figure 5b.

9

10 At step 2, the user initiates the printing process, by selecting a

11 printing option on a user interface (UI) (not shown). This causes the

12 PoD tool, referenced as 52e in Figure 3, to open a printing UI in a

13 conventional manner. Using the printing UI the user requests the

14 number of prints and various other printing parameters (e.g. whether

15 the printed document is to be in colour or black and white, etc.). At

16 step 4, the PoD tool 52e identifies from the document file name that

17 the document is a document having a position identifying pattern on

18 it. The PoD tool 52e then identifies those printers on the network

19 which the user may select to print the print job, at step 6. In the

20 present example, this includes the printer 60. The user selects the

21 printer 60 and initiates the print operation, in a conventional manner,

22 at step 8.

23

24 In the present embodiment, the printer 60 is a conventional laser

25 printer with a resolution of 600dpi, such as is conventionally used in

26 office environments. The Hewlett-Packard Laserjet 4550n and the

27 Hewlett-Packard Laserjet 9000n are examples of such of laser

28 printers. In the present embodiment, the printer is a monochrome

29 printer having a single conventional black toner cartridge (not

30 shown), printing with UV absorbing black toner. In other

1   embodiments however, the printer 60 may be a colour printer,

2   typically printing in black and three complementary colour inks.

3

4   The printer 60 has a conventional object database, or memory 60a,

5   which is illustrated in Figure 3. Such memories are used to store

6   various variables that are relevant to the operation of the printer 60.

7   For example, the colour of the toner cartridge in the printer (or each

8   of the cartridges if there are more than one) is stored in the memory

9   60a. In the present embodiment, the printer stores in the memory

10 60a a value corresponding to the cumulative number of pages so far

11 printed with the current cartridge. This may be implemented in a

12 conventional manner. Such techniques are well understood in the art

13 and so will not be described here. From this value, it may be

14 approximately calculated or determined, or even inferred, how much

15 toner remains in the cartridge, as is described in more detail below.

16

17 Although, a laser printer is used in the present embodiment, in other

18 embodiments of the invention other suitable types of printer may be

19 used. These may include inkjet printers, LED printers, LCD printers,

20 Liquid Electrophotographic Printers. Photocopiers can also be

21 considered as printers. The difference between an electrostatic,

22 toner-based photocopier, for example, and a laser printer is not

23 significant for many aspects of the invention. Indeed, it is not

24 uncommon for computers, e.g. PCs to be configured to print from

25 photocopiers. It will, thus be understood that the term "ink" is meant

26 to include liquid inks, and powder inks (e.g. toner that needs heat to

27 fuse to a page/surface) and gels: it is not used in a sense to restrict

28 its physical form. Furthermore, it will be understood that other

29 suitable printers also have a memory, similar to the memory 60a, for

30 storing information from which the quantity of ink still remaining in

1 the cartridge or ink supply etc. employed in the printer may be at

2 least approximately obtained.

3

4 Once the actual print is initiated, the PoD tool 52f allocates a unique

5 instance ID to the printed document, at step 10. It then requests the

6 required amount of pattern space from the database 52d of pattern

7 data, at step 12, providing the document name and instance ID. In

8 the current example, the requested pattern area is sufficient to cover

9 substantially all of the document, in this example a sheet of A4

10 paper, as stated above. For other examples, only some areas of the

11 document will need to be allocated a digital pattern.

12

13 An area of pattern is allocated at step 14 to the document from a

14 virtual pattern space stored in the database 52d. In the present

15 example, the PoD tool 52e receives back from the database 52d a

16 definition of the pattern space allocated. In the present embodiment,

17 this is in the form of a co-ordinate reference within the total pattern

18 space. This may take the form of, for example, upper left and lower

19 right co-ordinates of the allocated area in the pattern space. The

20 workstation 51 is then able to re-create the dot pattern in the

21 allocated area from that information in a conventional manner. In

22 other embodiments, a full definition of the actual pattern to be used

23 may be transmitted from the database 52d to the PoD tool 52e. Such

24 a full definition may take the form of co-ordinate positions, for

25 example, of each dot in the allocated area.

26

27 At this stage, it will be appreciated that the definition of the dot

28 pattern contains the nominal, or ideal positions of the dots which lie

29 in the allocated pattern space. Furthermore, the size and form of the

30 individual dots in the allocated pattern space are defined only by the

31 specification of the system. In the case of the Anoto system, for

1   example, the dots are circular with a diameter of approximately
2   100µm.

3

4   The PoD tool 52e then obtains, at step 16, data relating to the
5   amount of toner that is remaining in the cartridge associated with the
6   printer 60. In order to achieve this, the memory 60a of the printer 60
7   is interrogated by the PoD tool 52e.   The skilled reader will
8   appreciate that this may be done either directly by the PoD tool 52e
9   or by an interrogating entity.   The interrogating entity may take the
10   form of a software routine or program, such as an object database
11   client.   Alternatively, the interrogating entity may be implemented
12   using hardware or firmware.   Various methods of interrogating the
13   memory 60a are known.   However, in the present embodiment, the
14   TCP/IP (Transmission Control Protocol/Internet Protocol) protocol,
15   SNMP (Simple Network Management Protocol) is used.   HP Webjet
16   Admin, available from Hewlett-Packard, is one example of a
17   peripheral management software tool which may be used to
18   implement this function.

19

20   The PoD tool 52e then determines, at step 18, the characteristics of
21   the dots which will make up the digital pattern in the digital document
22   which is to be printed.   This is carried out in dependence upon the
23   data relating to the amount of toner that is remaining in the cartridge
24   associated with the printer 60.   In the present embodiment, when it is
25   determined that the cumulative number of pages already printed with
26   the current cartridge is less than a given threshold value, dots having
27   a first set of characteristics are selected for use in the digital pattern.
28   However, when it is determined that the cumulative number of pages
29   already printed with the current cartridge is equal or greater than the
30   given threshold value, dots having a second or different set of
31   characteristics are selected for use in the digital pattern.

1

2   In this manner, the dots which make up the digital patterns printed by

3   the system of the present embodiment may have variable or different

4   characteristics. In the present embodiment these characteristics are

5   controlled to vary with the remaining level of toner in the cartridge of

6   the printer. By changing the characteristics of the dots of the digital

7   patterns in dependence upon the current toner level of the toner

8   cartridge, digital patter may be printed by the system of the present

9   embodiment that may be more reliably read by the pen 20 throughout

10   the life of the cartridge.

11

12   Referring now to Figures 6a and 6b, exemplary pattern areas

13   illustrating sets of dots of differing characteristics according to the

14   present embodiment are illustrated. In Figure 6b, dots having a first

15   set of characteristics according to the present embodiment are

16   illustrated. In Figure 6a, dots having a second set of characteristics

17   according to the present embodiment are illustrated. In each case,

18   the dots form part of an exemplary digital pattern. In the current

19   example, the exemplary digital patterns conform to the type of digital

20   pattern employed in the Anoto system.

21

22   It will be understood by the skilled reader that the representations of

23   dot patterns illustrated in Figures 6a and 6b are schematic, or

24   idealised illustrations.   These schematic illustrations may most

25   closely resemble a raster image or bit map of the dots prior to being

26   printed. This may be as generated in application software, such as

27   the PoD tool 52e, or as in the data processed by the printer driver

28   52i, prior to being sent to the printer 60.   It will of course be

29   appreciated that when the dots are in fact printed, the printed shape

30   of a dot may vary somewhat from the schematic shapes illustrated.

31   This may be due to several factors.   One of these is due to

1 imperfections of the print engine, which causes its printed output to

2 be only an approximation of the pre-printed image.

3

4 For ease of explanation, each of the figures is shown against an

5 imaginary background grid. Each of the individual squares making

6 up the grid represent the smallest individual unit of addressable

7 printable area; i.e. the smallest individual unit of area which may be

8 printed by the printer 60. Thus, the grid represents the native

9 resolution of the printer. Thus, each of the pixels which may be

10 printed by the printer 60 substantially fills a given square. It will thus

11 be understood that since the native resolution of the printer 60 is

12 600dpi, the length of each of the individual squares making up the

13 grid is 42.3μm.

14

15 Turning now to Figure 6b, four dots 84a-d which have a first set of

16 characteristics according to the present embodiment are illustrated.

17 Each of the four dots 84a-d is positioned adjacent a different

18 corresponding point of intersection between imaginary gridlines (not

19 shown). The intersection points are indicated by crosses 82. The

20 crosses 82 are separated from their immediate neighbours in the

21 horizontal and vertical directions by 7 individual squares. This

22 equates to 296.3μm, which is approximately equal to the 300μm used

23 in the Anoto system. Each of the dots 84a-d occupies a different

24 position (i.e. above, to the right, to the below and to the left,

25 respectively) relative to its corresponding cross; thus illustrating the

26 four encoding positions employed in the Anoto system.

27

28 Referring now to the individual dots 84a-d, it can be seen from the

29 figure that each of the dots 80a-d is made up of four pixels arranged

30 in an "T" shape. It will in fact be clear to the skilled reader that

31 rotating dot 84c, for example, +90, 180 and +270 degrees about its

1   adjacent cross yields the orientational and positional relationship of

2   dots 84d, 84a and 84b, respectively, relative to their respective

3   adjacent crosses.

4

5   It has been found that Anoto type digital patterns, made up of dots

6   with the characteristics of dots 84a-d, printed with a range of 600dpi

7   laser printers may generally be reliably read by the pen 20;

8   particularly when printed during the phase of a cartridge's life when

9   the level of toner in the printer cartridge is relatively full. It will thus

10 be appreciated that dots of these characteristics have been found

11 under these circumstances to satisfy the requirements of the Anoto

12 system, discussed above. It has also been found that dots which are

13 significantly smaller than the dots 84a-d may not be reliably read

14 during this phase of the cartridge's life. However, in the present

15 embodiment, as the toner cartridge degrades with time and the level

16 of remaining toner falls, the size of the printed dots progressively

17 increases. Thus, as the dot size increases the dots 84a-d eventually

18 reach a size at which they are no longer reliably read by the pen 20.

19

20 Turning now to Figure 6a, four dots 80a-d are illustrated. The dots

21 80a-d have a second set of characteristics according to the present

22 embodiment, as are described below. As was the case in Figure 6b,

23 each of the four dots 80a-d is positioned adjacent a different

24 corresponding point of intersection between imaginary gridlines (not

25 shown). Again, the intersection points are indicated by crosses 82,

26 which are again separated from their immediate neighbours in the

27 horizontal and vertical directions by 296.3µm. Again, each of the

28 dots 80a-d occupies a different position (i.e. above, to the right, to

29 the below and to the left, respectively) relative to its corresponding

30 cross; again, illustrating the four encoding positions employed in the

31 Anoto system.

1

2   Referring now to the individual dots 80a-d, it can be seen from the

3   figure that each of the dots 80a-d is made up of three pixels

4   arranged in an "L" shape.   As was the case with the dots 84a-d,

5   rotating the dot 80c, for example, +90, 180 and +270 degrees about

6   its adjacent cross yields the orientational and positional relationship

7   of dots 80d, 80a and 80b, respectively, relative to their respective

8   adjacent crosses.   It will be understood that the dots 80a-d comprise

9   one less pixel and have a different form to that of the dots 84a-d.

10   Thus, it will be understood that the dots 80a-d, when printed, have a

11   smaller surface area or size than do the dots 84a-d, at any given

12   stage of the life of the toner cartridge.

13

14   It has been found that Anoto type digital patterns, made up of dots

15   with the characteristics of dots 80a-d, printed with the same range of

16   printers mentioned above, may be reliably read by the pen 20, when

17   the level of toner in the printer cartridge is relatively low at the time

18   of printing.   In particular, it has been found that digital pattern printed

19   with dots with the characteristics of dots 80a-d may be reliably read

20   when the pattern is printed during the phase of the cartridge's life

21   during which pattern printed with dots of the characteristics of the

22   dots 84a-d may no longer reliably read by the pen 20.   It will thus be

23   appreciated that dots of having the characteristics of the dots 80a-d

24   have   been   found   under   these   circumstances   to   satisfy   the

25   requirements of the Anoto system, discussed above.

26

27   Returning now to Figure 4b, at step 18 of the method, the PoD tool

28   52e selects the type of dots, or the characteristics of the dots for use

29   in printing the current digital document.   Thus, at step 18, the PoD

30   tool 52e selects the characteristics of dots 84a-d in order to generate

31   the digital pattern if it has been determined at step 16 that the

1   cumulative number of pages already printed with the current
2   cartridge is less than a given threshold value. Alternatively, the PoD
3   tool 52e selects dots of the characteristics of dots 80a-d in order to
4   generate the digital pattern if it is determined that the cumulative
5   number of pages already printed with the current cartridge is equal or
6   greater than the given threshold value. Thus, a first set of dots with
7   a given set of characteristics are used if the toner cartridge is
8   relatively full; and, a second set of dots with a different set of
9   characteristics are used if the toner cartridge is relatively empty.
10
11 It will of course be appreciated that for a given experimental set up, a
12 desirable point at which to set threshold value may be determined
13 using conventional experimentation techniques.
14
15 In certain cases, where a digital document has more than one page,
16 the PoD tool 52e may use dots having the first set of characteristics
17 for generating the digital pattern for one or more pages of the
18 document and may use dots having the second set of characteristics
19 for generating the digital pattern for a further one or more pages.
20 This may occur, for example, in the case where it is determined by
21 the the PoD tool 52e that the cumulative number of pages printed by
22 the current toner cartridge of the printer 60 will be incremented past
23 the threshold value during the printing of the current digital
24 document.
25
26 At step 20 of Figure 4b, the PoD tool 52e in conjunction with the
27 workstation 51 re-creates the dot pattern which is to be printed, using
28 dots with the characteristics selected at step 18. In the present
29 embodiment, the information defining the characteristics of the
30 selected dot type is stored locally with respect to the workstation 51,
31 in the memory 52b of the PC 52. However, in other embodiments,

1 this information may be stored on a server connected to a network

2 such as a LAN or the Internet 62, or indeed in a memory associated

3 with the printer that is to be used, such as the memory 60a. The

4 PoD tool 52e then converts the re-created dot pattern into a print file

5 ready for printing in a conventional manner.   In the present

6 embodiment, the dot pattern which is to be printed is re-created as a

7 bit map, although any other suitable format may instead be used.

8

9 At step 22, the print file is then converted into a language that can be

10 understood by the printer driver 52i (illustrated in Figure 3)

11 associated with the workstation 51 and is sent to the printer driver

12 52i.   Examples of a suitable language are PCL5 or Postscript.

13 However, other languages may instead be used.

14

15 At step 24, the print file is sent to the printer 60, where the document

16 is printed.

17

18 As is well understood in the art, human-discernable content normally

19 undergoes a half-toning and masking operation prior to printing in

20 order to determine what content, if any, is printed at each pixel of the

21 printing operation.   However, it will be understood that the digital

22 pattern may bypass a half-toning operation.   In the present

23 embodiment, the pixels of the digital pattern may either be "on" or

24 "off", with no shades of intensity between those extremes.   The

25 digital pattern data may be sent from a colour separation stage

26 directly to a masking stage, or even directly to the printer.

27

28 It will also be appreciated that where the digital document is to be

29 printed on the same carrier as human-discernible content, it may be

30 desirable to use inks with different characteristics. For example, the

31 digital pattern may be printed using an ink that absorbs IR radiation

1 and the human-discernable content may be printed using human

2 readable, IR transparent ink. In this manner, the risk of the human-

3 discernable content obscuring or masking the digital pattern may be

4 avoided.

5

6 In one such embodiment of the invention, a four-colour laser or inkjet

7 printer may be used. The digital patter is printed using an infra-red

8 absorbing black ink. The human-discernable content is printed using

9 cyan, magenta and yellow inks that are not infra-red absorbing. In

10 this embodiment, the black ink channel is processed separately from

11 the cyan, magenta and yellow channels. In this manner, the human-

12 discernable content and the digital pattern may be maintained

13 separate. This and other methods of simultaneously printing human-

14 discernable content and the digital pattern with laser and other types

15 of printers are more fully described co-pending British patent

16 application, incorporated by referenced above, entitled "Methods,

17 apparatus and software for printing location pattern", (Hewlett-

18 Packard reference 200300566-1; Attorney docket JL3824).

19

20 From the above description it will be understood that the printing

21 characteristics of printers vary between printer types and models. In

22 the above description examples of dot characteristics have been

23 given that have been found to work well with a range of printers.

24 However, it will be appreciated by the skilled reader that the optimal

25 dot characteristics will vary with the system used. The optimal dot

26 characteristics for a given system may be determined using

27 conventional experimental techniques. Thus, the optimal dot

28 characteristics for a given system may vary from the examples given

29 in various ways. These may include, but are not limited to, the use

30 of dots having a different: number of pixels; shape; size; orientation;

1   relative position; and colour, relative to the dots in the examples

2   described.

3

4   FURTHER EMBODIMENTS

5   In the above description numerous specific details are set forth in

6   order to provide a thorough understanding of the present invention.

7   It will be apparent however, to one skilled in the art, that the present

8   invention may be practiced without limitation to these specific details.

9   In other instances, well known methods and structures have not been

10 described in detail so as not to unnecessarily obscure the present

11 invention.

12

13 Although the above-description was described with reference to two

14 types of dots, having different characteristics, which may be used

15 with Anoto type patterns, it will be appreciated that other dots having

16 different characteristics may also be usefully employed in conjunction

17 with embodiment of the present invention.   A more complete

18 description of dots that may be used in printing digital patterns of the

19 Anoto type is given in co-pending US Patent Application Serial

20 No._____, incorporated by referenced above, entitled

21 "Location Patterns And Methods And Apparatus For Generating Such

22 Patterns" (HP reference 200310542-1; Attorney docket 621241-9).

23

24 Furthermore, although the above-description was described with

25 reference to the printing of an Anoto type pattern, it will of course be

26 understood that other position identifying patterns may equally be

27 used in conjunction with embodiments of the present invention.

28 Some examples of other suitable patterns are described in WO

29 00/73983 and WO 01/71643.

30

1   Furthermore, although in the above-described embodiment two sets
2   of dots having different characteristics were employed for use in
3   printing digital patters at different levels of toner depletion, or
4   cartridge wear or deterioration, it will be appreciated that in other
5   embodiments, this may be varied. For example, in one embodiment,
6   three or more phases of the life of the cartridge may be identified.
7   Each of these phases may have associated with it a corresponding
8   set of dots with characteristics suitable for use during that phase.
9   Furthermore, it will be appreciated that an appropriate number of
10   sets of dots and phases of the life of the cartridge will depend greatly
11   on the system used and may also be determined experimentally.

12

13   Although in the above description the dots having the first set of
14   characteristics were of a different shape to those having the second
15   set of characteristics, it will be appreciated that this need not be the
16   case in other embodiments. In certain embodiments the dots having
17   the first set of characteristics and the dots having the second set of
18   characteristics may be of the same shape.   In some such
19   embodiments, the dots having the first set of characteristics and the
20   dots having the second set of characteristics may be of the same
21   shape but a different size, for example. In one example, the dots
22   having the first set of characteristics may be made up of a three by
23   three square array of pixels.   The dots having a second set of
24   characteristics may be made up of a two by two square array of
25   pixels.

26

27   Such embodiments, where dots made up of a relatively high number
28   of individual pixels are used, may be more usefully applied to
29   operational set ups where the printer used has a comparatively high
30   resolution; for example a 1200 dpi printers, such as the Hewlett-
31   Packard Laserjet 5000dn laser printer. In such cases, a relatively

1   large increase in the number of pixels used to print each dot need

2   not necessarily result in an unacceptably big increase in the size of

3   the printed dots. Thus, it will be appreciated that embodiments of the

4   present invention may be used in conjunction with printers of higher

5   or lower resolution than 600dpi described above.

6

7   Although in the above-described embodiment, characteristics of the

8   dots making up a digital pattern are varied in dependence upon the

9   amount of ink remaining in the ink supply, it will be appreciated that

10   other printing related variables which affect the detectability of the

11   dot pattern by a pattern reader, or pen 20, may also be used to vary

12   the characteristics of the dots printed.   One example includes

13   atmospheric conditions, such as humidity and temperature.